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Chapter 6-6

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6.6 River Morphology

6.6.1 River Channel Planform Changes

■ Objectives

Rivers display a dynamic pattern of meandering over time. A comparison of river channel planforms — channel width and alignment — over time can provide a record of past changes in the channel and indicate future meandering and bank erosion tendencies. The focus of this assessment was the lowland valleys of the Tillamook Bay basin, because planform changes are more discernable in these low-relief, unconstrained areas, and because bank erosion concerns are more predominant here. The objectives of the assessment were to evaluate: 1) the change in river channel widths over time; 2) the trends in channel migration; and, 3) the trends in channel stability.

■ Methods

Current USGS digital 1:24,000 topographic maps of the Tillamook Bay lowland valleys were used as base maps for the comparison. These maps were developed from aerial photographs taken between 1975 and 1980. The first topographic maps for the area were published in 1942 by the U.S. Army War Department at a scale of 1:62,500. These early maps were developed from aerial photographs taken in 1939. The 1939 maps were enlarged to the same scale as the current maps and compared together over a light table. The planforms of the 1939 rivers were transferred to the current maps by tracing. There may be significant errors associated with a comparison of different editions of USGS maps because of inaccuracies or inconsistencies in the horizontal plane coordinates. Errors were minimized by aligning road intersections, benchmark locations and other spatial features common to the two map periods and comparing discrete reaches of river only in the immediate vicinity of the aligned cultural features. A similar exercise was done with the 1955 quadrangle map series, with river planforms transferred to the current map base. Figure 6-6-1 shows a close-up of the Wilson River combining planforms from the three time periods. Due to the error involved in this type of a comparison, the resulting maps of river planform change are not necessarily accurate representations of river location, but they provide a general indication of river channel changes over time.

■ Discussion

The river channels in the Tillamook Bay lowlands display noticeable patterns of both meandering and stability. Meandering is most apparent in the head of the lowlands, where the rivers rapidly change gradient from the uplands. The upper reaches of the Trask and Wilson Rivers display progressive downstream channel migration over the time periods assessed. These river reaches generally coincide with reaches where riverbank soils are prone to erosion. Many stable reaches of river are apparent further downstream in the lowlands. Stability may be an indication of resistant geology or soils, the use of revetment or, conversely, of shallower river channel conditions where flood flows are not constrained to the channel, but overflow onto the floodplain before excessive flow velocities and bank erosion occur.

The actively meandering reaches of the rivers should be managed in a way that conserves and protects this natural function of the river. Meandering dissipates energy in flowing water and regulates the movement of sediment through the river system. The aerial photograph of the Wilson River after the November 1998 flood (Figure 6-6-2) shows sediment deposition on floodplain lands and patterns of remnant channels and swales on the floodplain. This complexity of changing channel, bank and floodplain conditions creates aquatic habitat for salmon and other species.

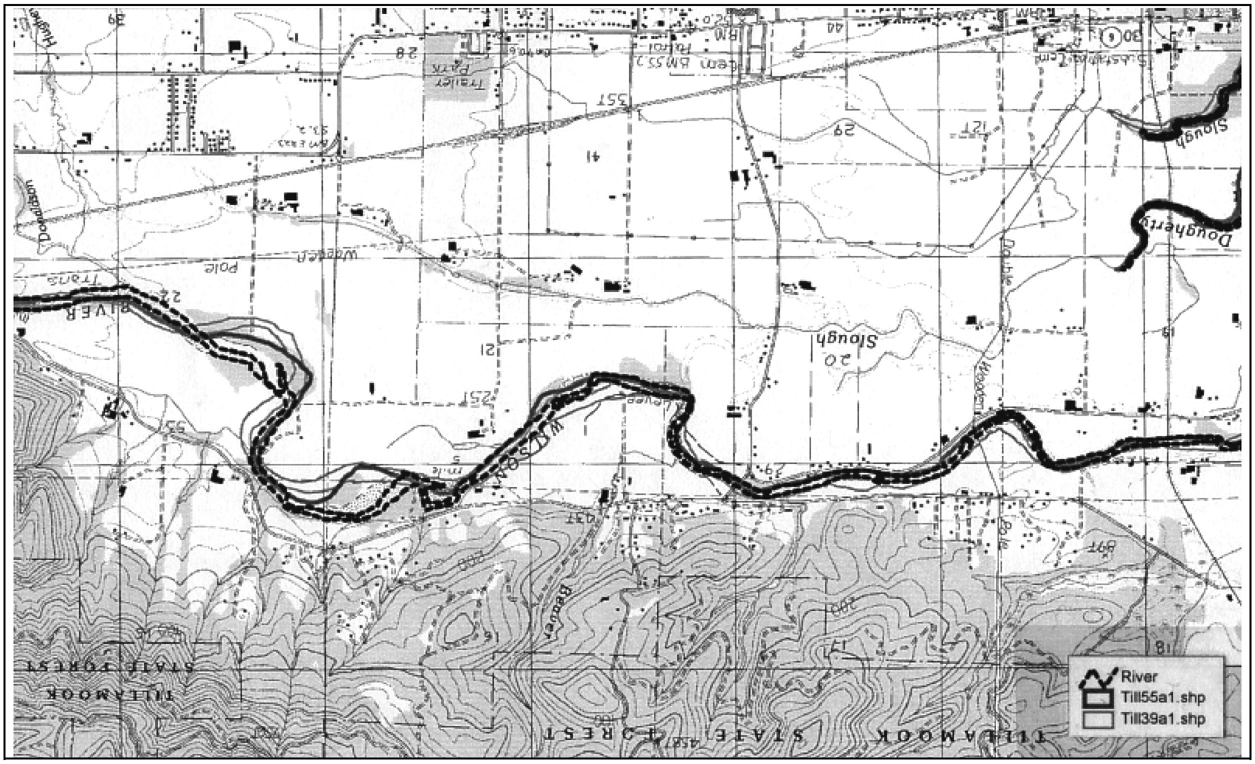


Figure 6-6-1. Detail of Wilson River Historic Planform Comparison Mapping

Figure 6-6-2. Aerial Oblique Photograph of 1998 Wilson River Flooding

6.6.2 Lowland Riverbank Stability and Erosion Assessment

■ Objectives

The erosion of riverbanks is a natural process that contributes to the progression of river meandering across a lowland valley. The erosion process can be accentuated by disturbances to the bank and by flooding. The stability of riverbanks is an issue where property ownership and land use interests seek long-term use of the land. These interests are often protected by physically covering the riverbank with rock, or by other methods. These protection efforts are typically done on an individual property-by-property basis. Although bank protection may provide a level of protection to the property of interest, it may have unintended consequences and impacts upstream or downstream along the river system. The objective of this assessment was to evaluate the stability of the natural river banks along the lowland river reaches to provide a comprehensive look at the relative stability of river banks for the entire lowland system.

■ Methods

A general indication of riverbank stability was established by adopting methods described in the Stream Restoration Handbook (Federal Interagency Stream Restoration Working Group, 1998). The soil survey for Tillamook was reviewed to identify the soil series along the banks of the lowland rivers. Soil interpretation records were obtained from the NRCS for these soils (Jasper, 1999). The soils records provide soils data for several depth classes. The surface depth class was generally not used in the assessment, in favor of soils associated with deeper classes that would be more susceptible to erosion from river flows. The soils series were grouped into soil types under the Unified Soil Classification System. The soils records provided data on moist bulk density in units of grams per cubic centimeter (gcc), which were converted to pounds per cubic foot (pcf) for a moist bulk unit weight [g]. The shear strength of the soils was estimated, assuming minimum values of cohesion and internal friction (U.S. Bureau of Reclamation, 1987). The Unified soil types were used to estimate minimum cohesion values [c] in pounds per square foot (psf). Referencing average engineering properties of compacted soils, a minimum friction angle [f] for each soil type was estimated, assuming unsaturated soil conditions.

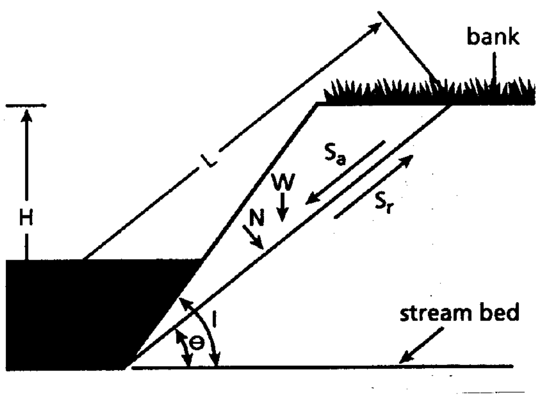
A stability number [N_s] was calculated for each soil type and for a range of bank angles [I] from 40 to 90 degrees using the relationship Ns = (4 sin I cos f)/(1-cos(I-f)). A critical bank height [H_c] was then calculated as a function of the geometry of the river bank, the soil properties and soil moisture conditions (Figure 6-6-3), where $H_c = N_s$ (c/g). Critical bank heights were estimated assuming "worst case" conditions, involving saturated banks and a rapid decline in river stage where the shear strength goes to zero, and unsaturated conditions. Accordingly, the process was repeated using a friction angle of zero to estimated stability under saturated soil conditions.

The resulting bank stability charts (Figures 6-6-4 through 6-6-7) show relationships between the critical bank height and the bank angle for the major lowland soil series. The upper line on the charts refers to critical bank heights for unsaturated conditions. Bank angles and heights above this line may present "unstable" conditions. The lower line represents critical bank heights for saturated conditions. Bank geometry conditions below this line may present "stable" conditions. Bank geometry conditions between the two lines may present "at risk" conditions for bank stability.

■ Discussion

A saturated 45 degree bank angle was assumed typical of riverbank slopes during flood conditions in the lowlands and was used to perform a comparison of the relative stability of the lowland riverbanks. The riverbanks with soils having H_c values rated as unstable or at risk were designated as unstable and plotted on a map. Figure 6-6-8 provides a sample of the resulting unstable riverbanks for the Wilson and Trask Rivers.

The unstable riverbank reaches generally coincide with the upper reaches of the lowland rivers. These reaches have experienced significant meandering, as observed from the river channel planform change assessment. These reaches of the rivers should be managed by setting back infrastructure and allowing meandering and bank erosion to occur.



Explanation

H = bank height
L = failure plane length
c = cohesion
Φ = friction angle
γ = bulk unit weight
W = weight of failure block
I = bank angle
S_a = Wsinθ (driving force)
S_r = cL + NtanΦ (resisting force)
N = Wcosθ
θ = (0.5I = 0.5Φ) (failure plane angle)

soil properties

for the critical case $S_a = S_r$ and:

$$H_c = \frac{4c \sin I \cos \Phi}{\gamma\,(1 - \cos\,[I - \Phi])}$$

Figure 6-6-3. Forces Acting on a Channel Bank Assuming there is Zero Pore-Water Pressure
Bank stability analyses relate strength of bank materials to bank height and angles, and to moisture conditions.

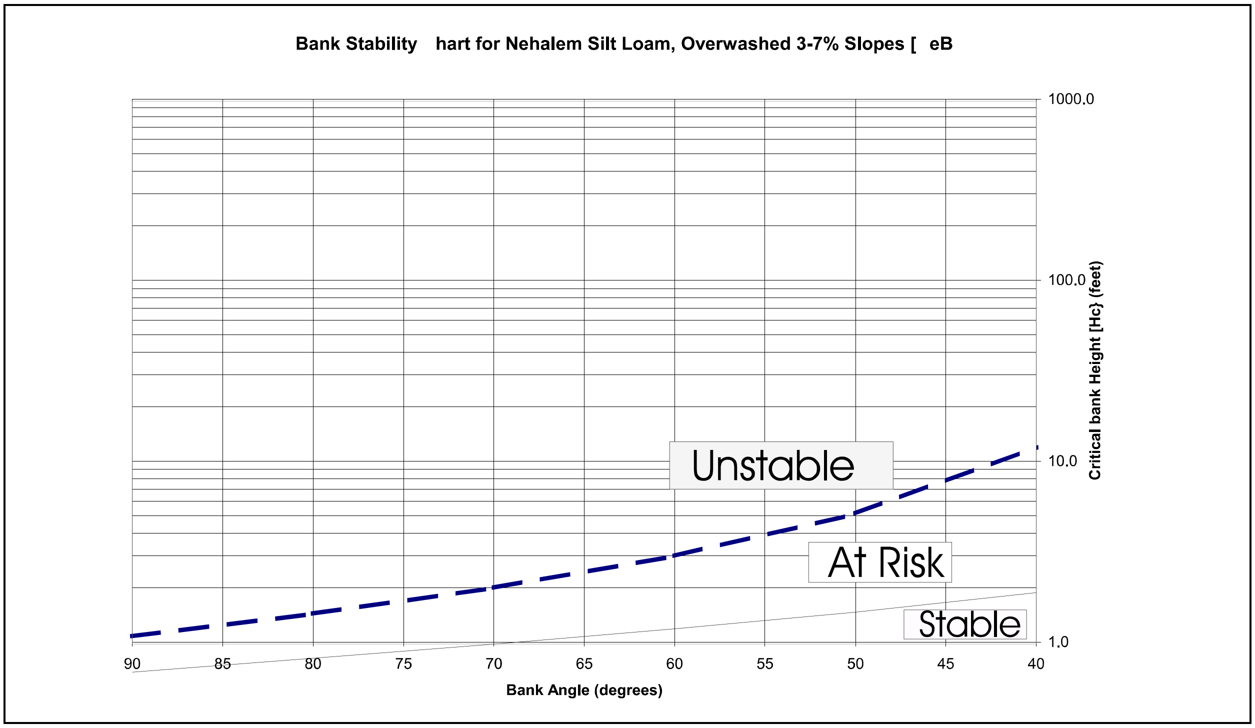


Figure 6-6-4. Bank Stability Chart for Nehalem Silt Loam, Overwashed 3-7% Slopes [NeB]

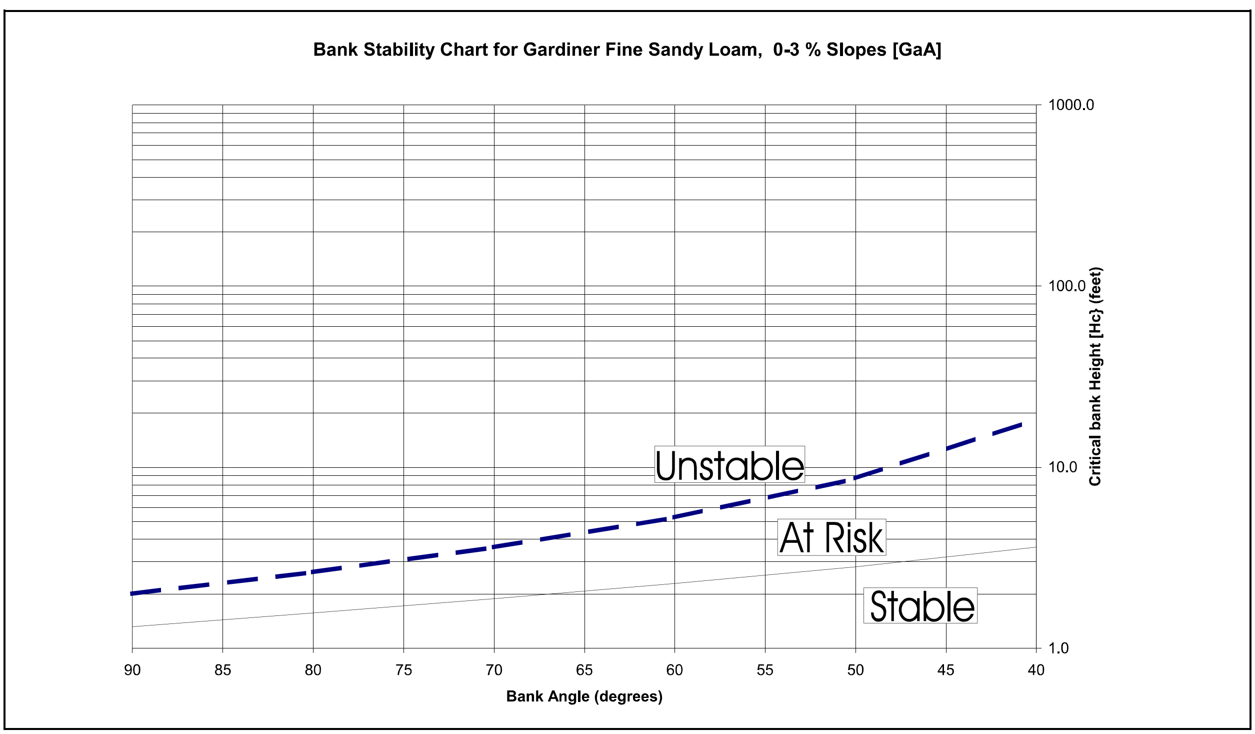


Figure 6-6-5. Bank Stability Chart for Gardiner Fine Sandy Loam, 0-3% Slopes [GaA]

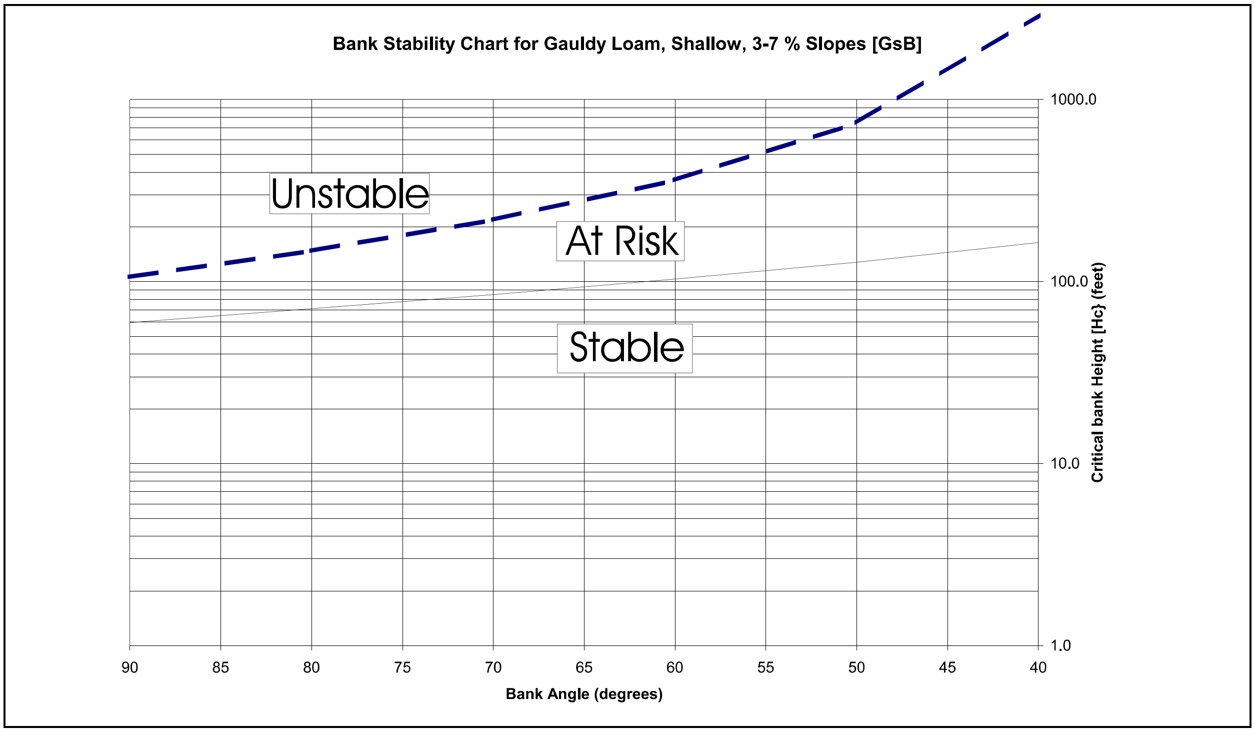


Figure 6-6-6. Bank Stability Chart for Gaudy Loam, Shallow, 3-7% [GsB]

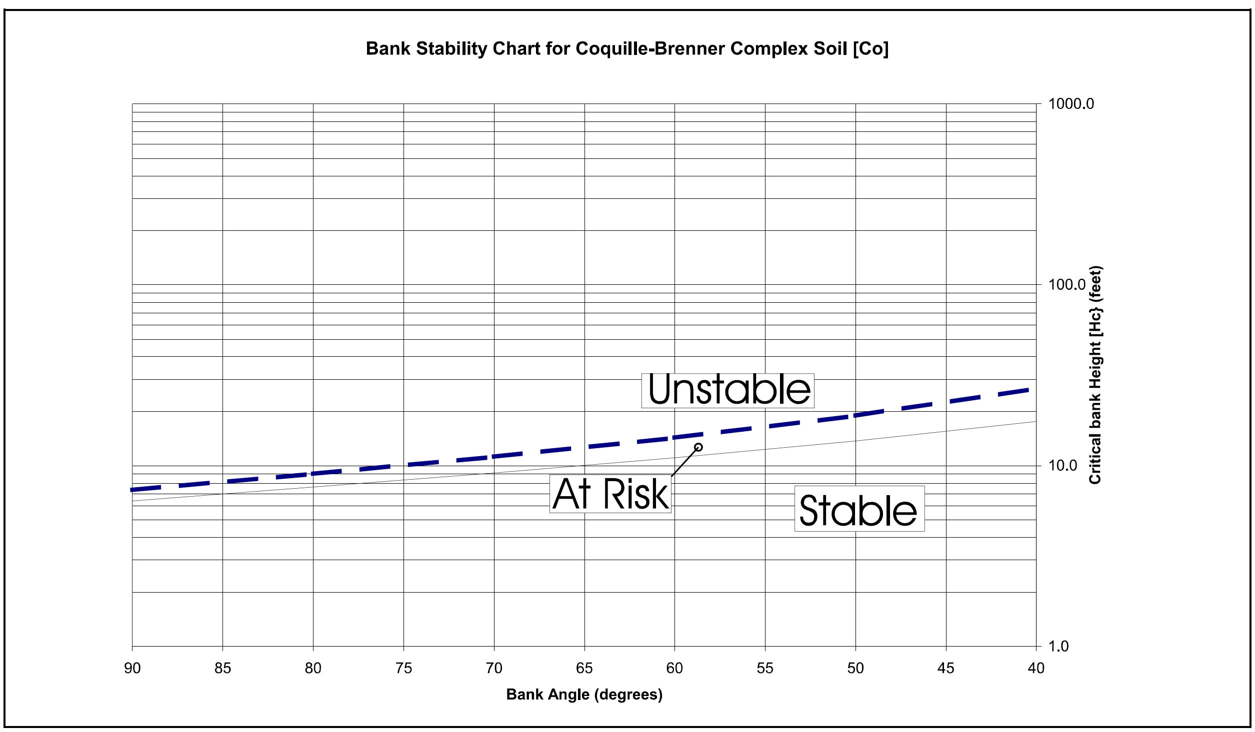


Figure 6-6-7. Bank Stability Chart for Coquille-Brenner Complex Soil [Co]

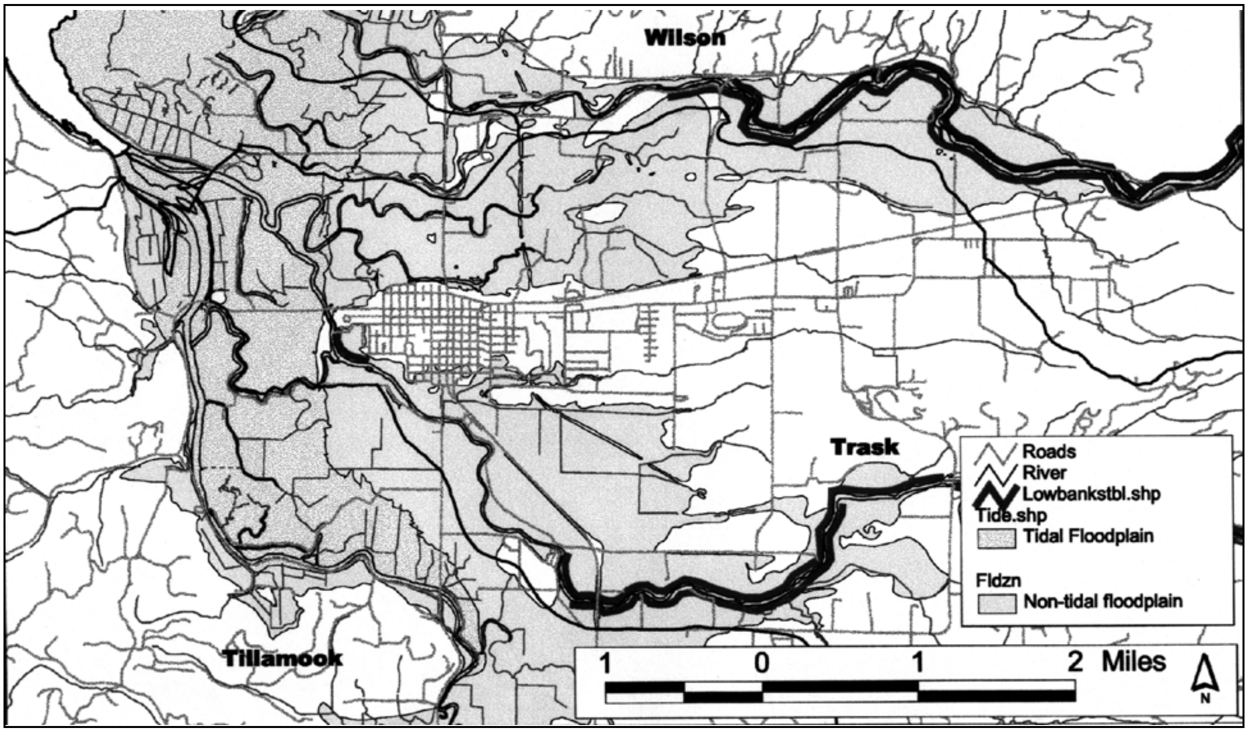


Figure 6-6-8. Unstable Riverbanks in the Tillamook Lowlands